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(54) **Reactor vessel stud cleaning machine.**

(57) A reactor vessel stud cleaning machine for cleaning reactor studs (102). The stud (102) is supported horizontally by a pair of roller carriage assemblies (104, 106) inside of a closed chamber (100). At least one roller carriage assembly (104, 106) has rollers (234) driven by a stud drive motor (114) which cause the stud (102) to rotate. As the stud (102) rotates, a spray nozzle (116) traverses the length of the stud (102) spraying a mixture of high pressure water and abrasive onto the stud (102). The spent water and abrasive is drained from the enclosure (100) and pumped through a separator funnel (132) and filter bank (148) to remove solids. The filtered water is returned to a supply tank (165) for reuse. The stud (102) rotation speed and spray nozzle traverse speed are variable as is the water pressure and rate of abrasive injection.

EP 0 144 237 A2

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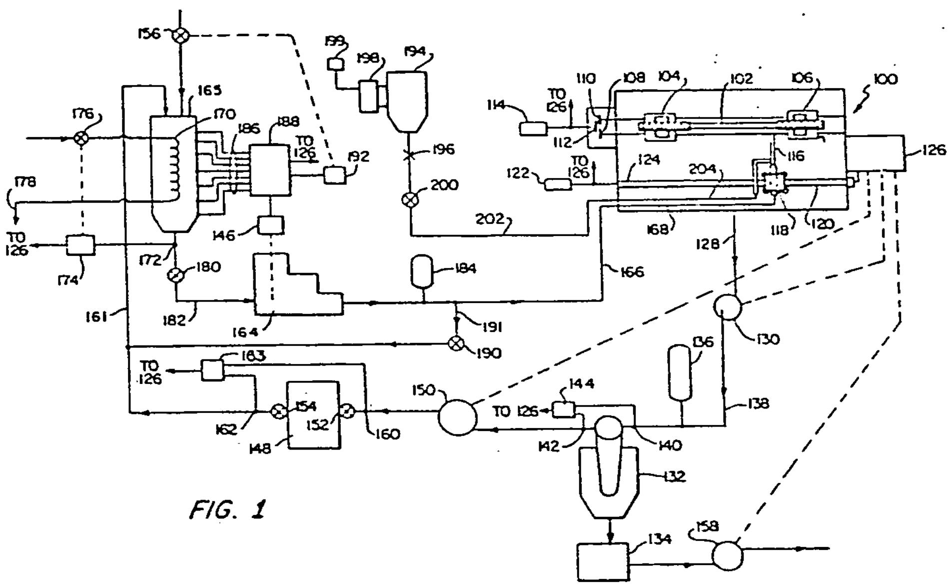

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FIG. 1

REACTOR VESSEL STUD CLEANING MACHINE

The present invention relates generally to an apparatus for cleaning and more particularly to an apparatus for cleaning cylindrical, elongated members such as nuclear reactor vessel studs.

A conventional nuclear reactor vessel is closed on the top by a member known as a reactor vessel head. During operation, the pressure vessel head is secured to the pressure vessel in a pressure tight manner. This is commonly accomplished by the use of a plurality of studs which are spaced about the circumference of a flange formed where the pressure vessel and pressure vessel head are joined.

During refueling and maintenance operations, the reactor pressure vessel head is routinely removed from the pressure vessel. Prior to reassembly, the studs used to join the heads to the vessels are cleaned for ease of reassembly and for non-destructive testing. In addition, a lubricant is used on the studs to facilitate reassembly. After removal, it is desirable that the old lubricant as well as any accumulated dirt and crud be removed so that the stud can be cleanly relubricated prior to its reuse.

To date, no adequate device for cleaning such studs has been developed.

Ransonoff, in U.S. Patent No. 2,632,980 discloses a method and apparatus for wet grit blasting of a liquid containing suspended grit particles. The liquid is blasted against an article to be cleaned. A centrifugal type pump

is used to form a liquid-grit suspension. The suspension is then sprayed from a projector nozzle at workpieces which may continuously advance through the grit blast on a rotating table or be batch tumbled in a rotary mill. Alternatively, the nozzle may be advanced relative to a stationary workpiece.

Nolan, in U.S. Patent No. 3,103,765 discloses a slurry blasting device wherein the workpiece and the blast gun are manually manipulatable. The device also includes an exhaust system which returns airborne abrasive particles to a slurry hopper for reuse.

Richter, in U.S. Patent No. 3,685,208 discloses a device for directing a high pressure jet against an advancing array of oscillating workpieces from above and below. A recovery system is employed to recapture the sprayed medium.

Kosar, in U.S. Patent No. 3,242,618 teaches a method for blasting and flush off with treatment of a large number of small manufactured parts without clamping or the like by tumbling the parts in a perforated drum, thus exposing all surfaces of the parts to processing.

Burack et al., in U.S. Patent No. 4,219,976 disclose a machine and method for decontaminating a nuclear steam generator channel with an assembly that is adapted to be positioned in the channel head and to sweep a blaster nozzle along an associated track in the head to decontaminate the area in the vicinity of the track.

Umbricht et al, in U.S. Patent No. 3,150,460 discloses a nozzle structure for blasting grit at the surface of an article to be cleaned.

Other systems for spraying abrasives, some of which teach various recovery systems, are disclosed in U.S. Patent Nos. 4,333,275; 4,330,968; 4,319,435; 3,455,062; 3,237,351 and 2,667,014.

None of the systems discussed above teach the use of a stud cleaning apparatus wherein the studs cleaned are rotated while a spray nozzle traverses the length of the

stud spraying a mixture of high pressure water and abrasive particles at the stud for cleaning and decontamination purposes.

It is therefore an object of the present invention to provide a method and apparatus for cleaning workpieces such as nuclear reactor pressure vessel studs.

One aspect of the invention resides broadly in a method of abrasively spray cleaning elongated members comprising supporting said elongated member and spraying said elongated member; rotating said supported elongated member; and in that said spraying of said elongated member is done with an abrasive spray while traversing said member while rotating said member.

Another aspect of the invention resides broadly in a device for cleaning an elongated member comprising a supporting arrangement for supporting said member within an enclosure; a spray nozzle disposed within said enclosure and operable to spray said cleaning agent against said member; an arrangement for supplying a cleaning agent to said spray nozzle; said supporting arrangement supporting said member being operable to rotate said member when driven; a first drive arrangement operably connected to and for driving said supporting arrangement; a second drive arrangement operatively connected to and for driving said spray nozzle; and said spray nozzle being driven by said second drive arrangement to traverse, in operation, a space adjacent said member.

It is a further aspect of the invention to provide a method and apparatus for cleaning nuclear reactor pressure vessel studs by rotating the studs in a closed chamber while traversing studs longitudinally with a spray of high pressure water and abrasive particles.

It is still a further aspect of the present invention to provide an apparatus for spray cleaning a rotating stud with a traversing abrasive spray nozzle while the stud rotation rate, the nozzle traverse speed, the

length of travel of the spray nozzle, the water pressure, and the rate of abrasive injection are all adjustable.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, as embodied and broadly described herein, the cleaning device of this invention may comprise roller carriage assemblies for supporting a member such as a reactor stud at ends thereof within an enclosure, at least one of the roller carriage assemblies being operable to rotate the member when driven. A drive means, preferably a dc motor, is connected to one of the roller supporting assemblies for rotating the member supported thereon.

A lead screw is disposed in the enclosure adjacent to the roller carriage assemblies and is operably connected to a second drive means, preferably a second dc motor, to be driven thereby. A spray nozzle is disposed within the enclosure and is operable to spray a cleaning agent against the member. The spray nozzle is driven by the lead screw to traverse the stud which occupies the space between the roller carriage assemblies. Means are also provided for supplying a cleaning agent to the spray nozzle.

Preferably, the cleaning agent comprises a mixture of high pressure water and abrasive grit and the supply means comprises a water supply tank and a high pressure pump connected to an outlet of the water supply tank, the outlet of the high pressure pump being connected to the spray nozzle. A grit tank is also connected to the spray nozzle, the spray nozzle being operable to mix and eject a spray of water and grit.

Preferably, a drain is provided in the enclosure for draining spent cleaning agent from the enclosure. A pump means is connected to the drain for removing the spent cleaning agent and transporting it through a separator and a filter bank for removing any entrained solids. The remaining liquid is returned to the water supply tank for recycling. Preferably, the high pressure pump is variable

in response to the cleaning requirements also operable to be shut down in the event the water level in the supply tank decreases below a predetermined minimum to prevent cavitation of the pump.

Preferably, the grit tank has an outlet which comprises a variable restricted flow opening operable to meter the grit being transported to the spray nozzle.

Preferably, both the lead screw drive motor and the stud drive motor are controlled so that the rate of rotation of the stud and the rate of traversal of the stud by the spray nozzle may be tailored to optimally clean the stud without exposing it to unnecessary risk of damage by the abrasive particles.

The accompanying drawings which are incorporated in and form a part of the specification, illustrate the presently preferred embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Figure 1 illustrates a schematic top view of the stud cleaner together with details of the water and grit supply system;

Figures 2A and 2B are block diagrams illustrating the control systems for the lead screw drive motor and the stud drive motor respectively;

Figures 3A and 3B are top and plane views respectively of the interior of the stud cleaning device enclosure.

Reference will now be made in detail to the presently preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

Referring first to Figure 1, reference 100 denotes a reactor stud cleaner enclosure. A reactor stud 102 is supported in the enclosure on a pair of roller carriage assemblies 104 and 106. Preferably only roller carriage assembly 104 is driven, preferably by means of sprockets 108, 110 and 112, through a stud drive motor 114. The position of roller carriage assembly 106 is preferably

adjustable with respect to roller carriage assembly 104 in order to accommodate studs of various lengths. Further details of the roller carriage assemblies are discussed below with respect to Figures 3A and 3B.

A spray nozzle 116, for spraying a mixture of high pressure water and abrasive at the stud is carried by a spray nozzle carriage 118. The spray nozzle carriage is engaged by a lead screw 120 which is preferably driven by a lead screw drive motor 122 through a linking member 124. As more fully detailed below with regard to Figures 2A and 2B, the rotation of the stud drive and the rotation of the lead screw drive motors are monitored by tachometer roto-ducers which provide input signals for control systems which control the stud drive motor 114 and the lead screw drive motor 122. All control systems may be conveniently disposed in a control and monitoring panel 126 attached to the enclosure 100.

The water and grit supply system of the stud cleaner will now be described. The enclosure has a drain 128 which feeds into a low pressure pump 130 such as a diaphragm pump which may be manually operated by means of solenoid valves and air manifolds (not shown) positioned in the control panel 126.

The output of the pump 130 is fed to a separator funnel 132 where any grit, abrasive, or crud entrained in the water stream as a result of the cleaning process is removed to a waste tank 134. It should be appreciated that other liquid-solid separating devices may be substituted for the funnel separator 132 within the scope of the invention. Preferably, the separator 132 is of the type sold by Dorr Oliver Corporation of Stamford, Connecticut, Model No. 3NZ-3A. A surge suppressor 136 may be positioned in the conduit 138 between the low pressure pump 130 and the separator 132 in order to absorb any pressure surges in that line. Pressure sensors 140 and 142 are preferably positioned on the inlet and outlet sides respectively of the separator 132. The pressure sensors are coupled to a

comparator and threshold device 144 to generate an alarm signal if the pressure difference between the inlet and outlet of the separator funnel 132 exceeds a predetermined maximum indicative of a clog or blockage. The output of the comparator/threshold device 144 may conveniently be connected to the control panel 126 where an appropriate gauge and/or enunciator (not shown) is positioned. The signal from the comparator/threshold circuit 144 may also be used as an automatic shutdown signal to deenergize the stud drive motor 114, the lead screw driver motor 122 as well as a motor 146 for the high pressure pump 164. The operation of the high pressure pump motor 146 is further explained below.

The outlet of the funnel separator 132 is fed to a filter bank 148 through a second low pressure pump 150. The pump 150 may also comprise a diaphragm pump control from the control panel 126 by means of conventional solenoid valves and air manifolds (not shown). Filter bank 148 preferably comprises a dual filter bank of the type marketed by Dover Corporation of Portage, Michigan, Model No. CST-224DUO-SE having 2 three-way ball valves or the like 152 and 154. As will be apparent, with the use of a dual filter bank, one bank of filters can be connected in-line while the second bank is having the filter basket replaced or cleaned. The ball valves 152 and 154 can be manually operated for that purpose.

A third low pressure pump 158 is used to drain the waste tank 134 to a conventional hittman cask (not shown) or the like where any radioactive residue from the stud cleaning operation can be safely stored.

Preferably, pressure sensors 160 and 162 are positioned at the inlet and outlet side respectively of the filter bank 148 and connected to a second comparator-threshold detector 163 which generates a signal if the pressure differential across the filter bank gets excessively high indicating a clog, blockage, or the like. A signal from the comparator-threshold detector 163 is

preferably fed to the control panel 126 to energize an indicator and/or enunciator (not shown) on the control panel 126 and may also be used to control the motors 114, 122, and 146 in the manner described above with respect to the funnel separator 132.

After passing through the filter bank 148, the fluid stream passes through a conduit 161 and into a water supply tank 165. Fluid is pumped from the water supply tank 165 by means of high pressure pump 164 driven by the pump motor 146. The pump outlet is fed to the spray nozzle 116 through a supply line 166 which includes a flexible portion 168 adapted to follow the movement of the spray nozzle 116.

The supply tank 165 is preferably provided with a cooler 170 which may be in the form of a cooling coil in order to reduce the temperature of the water before it passes through the high pressure pump 164 where it will undergo a considerable rise in temperature due to the pumping action. The cooler 170 is preferably controlled by a temperature sensor 172 which is connected to a valve control device 174 which controls a solenoid valve 176 which controls the flow through the cooling coil 170. The outflow from the cooling coil may be channeled to a drain through the conduit 178. The cooling medium in the coil 170 may simply comprise available tap water.

A manual ball valve 180 or the like may be provided on the outlet of the supply tank 165 in order to open, close or control the maximum flow through the conduit 182 which connects the water supply tank 165 to the high pressure pump 164.

Preferably, a pulse dampener 184 or the like is provided in the line 166 in order to dampen out any pressure pulses which may occur in the outflow of the high pressure pump 164. This is desirable in order to ensure that the flow of high pressure water to the nozzle 116 is of relatively constant, controllable pressure since an

excessive pressure surge may result in damage to the stud member.

A plurality of level sensors 186 are preferably provided in the supply tank 165. Sensors 186 are connected to a level indicator 188. If the level of fluid in the tank 165 becomes too low, make-up water is provided by means of a solenoid valve 156 and valve controller 192 respectively, in order to increase the level of water in the tank 165. If the level of fluid in the supply tank 165 falls below a dangerously low level, the pump 164 is shut down to prevent pump operation under cavitation conditions. The fluid level indicator 188 may also be connected to an indicator and/or enunciator (not shown) on the control panel 126. A relief valve 190 may also be provided for system over-pressure protection and for flow bypass from the output of pump 164 back to the supply tank 165.

As will be apparent to the artisan, the output of the pump 164 may also be controlled in order to regulate the water flow to the spray nozzle 116 in accordance with the cleaning requirements.

For example, the threaded portions of a stud are known to be more difficult to clean than smooth portions. Therefore, as the spray nozzle traverses the threaded portions of the stud, the pump pressure may be increased to enhance the abrasive action of the cleaning agent. This can be accomplished manually by the operator or can be accomplished automatically in connection with the control system for the lead screw drive motor 122 illustrated in Figure 2B and discussed below.

A grit pot 194, preferably equipped with a variable restricted orifice outlet 196, is provided for holding the abrasive material. The vibrator 198, preferably of the electromechanical variety, such as that marketed by FMC Corporation of Homer City, Pennsylvania, Model No. V-20 is attached to the grit pot to maintain a flow of grit through the restricted orifice 196. The vibrator may be controlled by a vibrator control 199 such as that

marketed by FMC Corporation of Homer City, Pennsylvania, Model No. SCR-1B. The size of the orifice 196 may be manually or automatically set to create a grit/water mixture of the proper proportions. It should be understood, that the orifice 196 operates as a metering orifice for the grit. A manually operated ball valve 200 may also be provided downstream of the orifice in order to control flow through the channel 202. The conduit 202 terminates at a flexible portion 204 which is connected to the spray nozzle 116 in order that the conduit 204 can follow the movement of the nozzle 116 in the same manner as the high pressure water supply conduit 168 discussed above.

As should now be apparent, the invention described above may be used to safely clean stud type members, even those carrying radioactive dirt and grit. The stud 102 is first placed horizontally on roller carriage assemblies 104 and 106 inside the closed chamber 100. While a horizontal stud carrying configuration is preferred, it should be apparent that it is within the scope of the present invention for the studs to be held in a vertical orientation during cleaning. The stud drive motor 114 is then energized causing the stud 102 to rotate. While the stud rotates, the spray nozzle 116 traverses the length of the stud while spraying a mixture of high pressure water and abrasive onto the stud. The spent water/abrasive mixture is drained to the bottom of the enclosure 100 and pumped by means of the pump 130 into the separator funnel 132 which removes any large solid particles. The remaining liquid is then pumped through the filter bank 148 to remove smaller particles, on the order of 2-3 microns in size. The filtered water is then returned to the supply tank 165 for reuse. Solids, which may be radioactive, are pumped by means of pump 158 from the waste collection tank 134 to a hittman cask and prepared for disposal in a conventional manner. Because of the topography of the stud and the cleaning requirements thereof, the stud rotation speed and spray nozzle traverse speed are variable. In addition, in

order to accommodate studs of various length, the length of travel of the spray nozzle and the distance between the roller carriage assemblies is variable.

By controlling the operation of the relief valve 190 and the orifice 196 respectively, the water pressure and rate of abrasive injection are both adjustable so that specific stud and stud portion cleaning requirements can be met while avoiding damage to stud material.

Turning to Figure 2A, there is depicted a control system for the stud drive mtor 114. The rotation of the shaft 208 is detected preferably by a tachrotoducer comprising a toothed wheel 209 and a detector 210. The output of the detector 210 is fed to a speed switch 211 and to a calibrator 212 and a tachometer 213.

Turning to Figure 2B, there is depicted a control system for the lead screw drive assembly. The rotation of a shaft 214 is detected preferably by a tachrotoducer comprising a toothed wheel 215 and a detector 216. In a manner similar to that described above with regard to Figure 2A, the output of the detector 216 is fed to a speed switch 217 which is operable to shut down the high pressure pump motor 146 in the event that the rotational speed of the lead screw falls below a predetermined minimum. As before, the pump output can also be controlled by means of a controllable, variable drive system such as a variable pulley drive or by controlling the amount of water bypassed through the line 191 back to the supply tank 165 by controlling the relief valve 190. In addition, the output of the detector 216 is fed to an input calibrator 218 and then to a tachometer 219 whose output is indicated by a dial, digital counter or the like, preferably positioned on the control panel 126.

In addition, the output of the detector 216 is fed to a preset counter 220 which may be of the type marketed by Electrical Counters and Controls Corporation of Mundelein, Illinois, Model No. SBL 135 which is operable to count the rotations of the shaft 214 in order to determine

the position of the spray nozzle 116 relative to the stud 102. The preset counter 220 is preprogrammed with information regarding the length of the stud, and the topography of the stud such as the position of the portions of the stud which are threaded, the portions which are smooth, etc. As alluded to above, when for example the spray nozzle is traversing a portion of the stud which is threaded, it is desirable to slow down the rate of traversal of the spray nozzle and the rate of rotation of the stud in order to ensure that the threaded area is properly cleaned. On the other hand, when the spray nozzle is traversing a smooth area of the stud, the rate of traversal of the spray nozzle and the rate of rotation of the stud may be increased while still achieving adequate results in terms of cleaning. Accordingly, high speed circuit 221 and low speed circuit 222 are provided which are activated by the preset counter 220 in accordance with the position of the spray nozzle 116 as determined by the preset counter 220. The high and low speed circuits 221 and 222 are operable to control the lead screw drive motor 122 through servomotor controller 223 in order to adjust the speed of traversal of the nozzle 116 in accordance with the requirements of the portion of the stud being traversed. In a similar manner, the outputs of the high and low speed circuits 221 and 222 respectively are fed to an SCR control device 225 in order to control the speed of rotation of the dc motor 114. It should be appreciated by the artisan that if a servomotor is substituted for the dc motor 114, a servomotor control will be substituted for the SCR control 225.

While the embodiment illustrated and described above relates to a simple two speed control of the lead screw and stud drive motors, it should be appreciated that any number of speeds can be used to precisely control the stud drive and lead screw drive, either jointly or independent of each other, in order to achieve optimum cleaning results and minimal damage or erosion to the stud. In

fact, it is within the scope of the present invention for the drive motors to be continuously controlled as a function of position of the spray nozzle 116.

Turning now to Figures 3A and 3B there are illustrated top and side views respectively of the inside of the cleaning compartment 100 of a stud drive cleaner according to the present invention. Elements similar to those illustrated in Figures 1 and 2A and 2B are similarly numbered in Figures 3A and 3B. As best seen in Figure 3A, a typical reactor stud 102 has threaded portions 224 and unthreaded portions, each of which have different cleaning requirements. The roller carriage assembly 106 is movable with respect to the roller carriage 104 and may be repositioned on the channel 226 by means of a locking key or the like in order to accommodate studs of various lengths. The channel 226 is rigidly secured to the frame 228 of the enclosure 100 by fasteners 230 which may comprise screws or the like. The carriage 106 is provided with a stop roller 232 to prevent the stud from moving to the right as it is rotated.

Each of the roller carriage assemblies has a pair of rollers 234 which are preferably supported on bearings 236 to ensure ease of rotation.

The spray nozzle position is adjustable by means of a ball and nut assembly (not shown) or the like so that the spray nozzle 116 may be properly positioned with respect to the stud.

The rollers 234 on the roller carriage 104 are driven through shafts 240 and 242 which have at their ends sprockets 110 and 108 respectively. The shafts are driven by the motor 114 through a gear reducer 244 whose output shaft 246 carries the sprocket 112. A chain 248 or the like may be used to drive the sprockets 108 and 110 from the driven sprocket 112. As alluded to above, the gear reducer 244 may be eliminated if a DC servomotor is substituted for the motor 114. It should also be appreciated that other stud drive means may be substituted for the

sprocket and chain drive illustrated within the scope of the present invention.

The spray nozzle carriage 118 preferably rides on a "way" or track 248 by means of engagement rollers 250 which seat in a groove in the track 248. The lead screw 120 is preferably protected against damage from grit or the like by bellows 252 and 254. The lead screw is journalled between support members 256 and 258. Each of the bellows 252 and 254 are preferably operable to extend between the spray nozzle carriage 118 and a support member 256 or 258 so that as the carriage 118 traverses the stud, the bellows 252 and 254 expand and contract in a complementary manner. Thereby, the progress of the carriage 118 is not impeded and the lead screw 120 is always covered in order to protect it against grit and abrasives.

The bottom 260 of the enclosure 100 is configured so that the water and grit from the spray nozzle 116 will collect at the drain 128 for recycling back to the supply tank 165.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiment was chosen and described in order to best explain the principles of the invention in its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

CLAIMS:

1. A method of abrasively spray cleaning elongated members (102 in Figs. 1, 3A) comprising:

supporting said elongated member (102 in Figs. 1, 3A) and spraying said elongated member (102 in Figs. 1, 3A);

characterized by rotating said supported elongated member (102 in Figs. 1, 3A); and

in that said spraying of said elongated member (102 in Figs. 1, 3A) is done with an abrasive spray while traversing said member while rotating said member.

2. A method of claim 1 characterized by varying the rate of rotation of said elongated member (102 in Figs. 1, 3A) during said traversing step.

3. A method of claim 1 or 2 characterized in that said elongated member (102 in Figs. 1, 3A) has a given surface topography and further including varying the rate of traverse of said high pressure spray as a function of said given surface topography.

4. A method of claim 1, 2 or 3 characterized in that said high pressure abrasive spray comprises a mixture of water from a high pressure water flow and a grit and further including the step of varying the flow of said high pressure water or said high pressure abrasive spray.

5. A method of claim 4 further including varying a flow of said grit.

6. A device for cleaning an elongated member (102 in Figs. 1, 3A) comprising:

a supporting arrangement (104, 106 in Figs. 1, 3A) for supporting said member (102 in Figs. 1, 3A) within an enclosure (100 in Fig. 1);

a spray nozzle (116 in Figs. 1, 3A) disposed within said enclosure (100 in Fig. 1) and operable to spray said cleaning agent against said member (102 in Figs. 1, 3A);

an arrangement for supplying (166, 202 in Fig. 1; and 168, 204 in Figs. 1, 3A) a cleaning agent to said spray nozzle (116 in Figs. 1, 3A);

characterized by said supporting arrangement (104, 106 in Figs. 1, 3A) supporting said member (102 in Figs. 1, 3A) being operable to rotate said member (102 in Figs. 1, 3A) when driven;

a first drive arrangement (108, 110, 112 in Figs. 1, 3A; and 114 in Figs. 1, 2A, 2B, 3A, 3B) operably connected to and for driving said supporting arrangement (104, 106 in Figs. 1, 3A);

a second drive arrangement (120, 124 in Figs. 1, 3A, 3B; and 122 in Figs. 1, 2A, 3A, 3B) operatively connected to and for driving said spray nozzle (116 in Figs. 1, 3A); and

said spray nozzle (116 in Figs. 1, 3A) being driven by said second drive arrangement (120, 124 in Figs. 1, 3A, 3B; and 122 in Figs. 1, 2A, 3A, 3B) to traverse, in operation, a space adjacent said member (102 in Figs. 1, 3A).

7. A cleaning device of claim 6 characterized in that said supply arrangement (166, 202 in Fig. 1; and 168, 204 in Figs. 1, 3A) comprises:

a grit tank (194 in Fig. 1) for holding grit connected to said spray nozzle (116 in Figs. 1, 3A);

said spray nozzle (116 in Figs. 1, 3A) being operable to mix and eject a spray of water and grit.

8. A cleaning device of claim 6 or 7 characterized in that said supply arrangement (166, 202 in

Fig. 1; and 168, 204 in Figs. 1, 3A) further comprises:

a drain (128 in Figs. 1, 3A, 3B) in said enclosure (100 in Fig. 1) for draining spent cleaning agent;

a pump (130 in Fig. 1) connected to said drain (128 in Figs. 1, 3A, 3B) for removing said spent cleaning agent from said enclosure (100 in Fig. 1);

a separator arrangement (132 in Fig. 1) connected to said pump (130 in Fig. 1), and operable to remove solid particles from said spent cleaning agent; and

an outlet of said separator arrangement (132, 148 in Fig. 1) being connected to recycle water.

9. A cleaning device of claim 8 characterized in that said separator arrangement (132, 148 in Fig. 1) comprises:

a funnel separator (132 in Fig. 1); and

a filter bank (148 in Fig. 1), connected for removing any fine particles passing through said funnel separator (132 in Fig. 1).

10. The cleaning device of claim 9 characterized by a first arrangement (140, 142, 144 in Fig. 1) for monitoring a pressure drop across said funnel separator (132 in Fig. 1) and providing a signal when said pressure drop exceeds a given value.

11. The cleaning device of claim 9 or 10, characterized by a second arrangement (160, 162, 163 in Fig. 1) for monitoring a pressure drop across said filter bank (148 in Fig. 1) and providing a signal when said pressure drop exceeds a predetermined value.

12. A cleaning device of any of the preceding claims characterized by:

a supply tank (165 in Fig. 1) for said water;

a cooling arrangement (170 in Fig. 1) disposed in said supply tank (165 in Fig. 1) for cooling said water;

a temperature sensor (172 in Fig. 1) for measuring the temperature of said water; and

a control arrangement (174, 176 in Fig. 1) for controlling said cooling arrangement (170 in Fig. 1) in response to the measured temperature.

13. A cleaning device of claim 12 characterized by a level detector (186, 188 in Fig. 1) for detecting a water level in said supply tank (165 in Fig. 1) and generating a low level signal if said level decreases below a predetermined minimum.

14. A cleaning device of claims 2 - 13, when claims 3 - 13 are dependent from claim 2, characterized by a vibrator (198 in Fig. 1) connected to said grit tank (194 in Fig. 1) for causing grit to flow through a grit tank outlet.

15. A cleaning device of claim 14 characterized in that said grit tank outlet comprises a variable, restricted flow opening for metering said grit.

16. A cleaning device of any of the preceding claims characterized by a first control arrangement (215, 216 in Fig. 2B; and 220 in Figs. 2B, 3A, 3B) for controlling said second drive arrangement (120, 124 in Figs. 1, 3A, 3B; 122 in Figs. 1, 2A, 3A, 3B; and 126 in Figs. 1, 2A, 2B), said first control arrangement (215, 216 in Fig. 2B; and 220 in Figs. 2B, 3A, 3B) comprising:

a rotation detector (215, 216 in Fig. 2B) for detecting the rotation of a shaft (214 in Fig. 2B) associated with said second drive arrangement (120, 124 in Figs. 1, 3A, 3B; and 122 in Figs. 1, 2A, 3A, 3B);

a programmable counter (220 in Figs. 2B, 3A, 3B) connected to said rotation detector (215, 216 in Fig. 2B) and operable to generate a speed signal whose value varies as a function of said rotation; and

a first drive control (114 in Figs. 1, 2A, 2B, 3A, 3B) connected to said programmable counter (220 in Figs. 2B, 3A, 3B) and operable to control said second drive arrangement (120, 124 in Figs. 1, 3A, 3B;

and 122 in Figs. 1, 2A, 3A, 3B) in accordance with said speed signal whereby said rotation is at a speed dependent upon the number of rotations of said shaft (214 in Fig. 2B) associated with said second drive arrangement (120, 124 in Figs. 1, 3A, 3B; and 122 in Figs. 1, 2A, 3A, 3B).

17. A cleaning device of claim 16 characterized in that said speed signal comprises a high speed signal and a low speed signal and said first control arrangement further comprises high and low speed signal circuits (221, 222, 223, 225 in Fig. 2B) positioned between said programmable counter (220 in Figs. 2B, 3A, 3B) and said first drive control (114 in Figs. 1, 2A, 2B, 3A, 3B).

18. A cleaning device of claim 17 characterized by a second drive control (209, 210, 212, 213 in Fig. 2A) for controlling said first drive arrangement (108, 110, 112 in Figs. 1, 3A; and 114 in Figs. 1, 2A, 2B, 3A, 3B) said second drive control (209, 210, 212, 213 in Fig. 2A) being connected to another programmable counter (212 in Fig. 2A) and operable to control the rate of rotation of said first drive arrangement in accordance with the number of rotations of said shaft (214 in Fig. 2A).

19. A cleaning device of any of the preceding claims characterized by a control system (208, 209, 210 in Fig. 2A) comprising a rotational speed detector (209, 210 in Fig. 2A) associated with said first drive arrangement (108, 110, 112 in Figs. 1, 3A; and 114 in Figs. 1, 2A, 2B, 3A, 3B) Fig. 1 and Fig. 3A) and an arrangement (200 in Fig. 1) operable to limit the supply of said cleaning agent to said spray nozzle (116 in Figs. 1, 3A) whenever the speed of rotation of a shaft (208 in Fig. 2A) associated with said first drive arrangement (108, 110, 112, 114 in Figs. 1, 3B) falls below a predetermined minimum.

20. A cleaning device of any of the preceding claims, characterized in that said supporting

arrangement (104, 106 in Figs. 1, 3A) further comprises:

first and second roller carriage (104, 106 in Figs. 1, 3A) assemblies spaced from each other within said enclosure (100 in Fig. 1, 3B); and

said first roller carriage assembly (104 in Figs. 1, 3A) comprising a pair of support rollers (234 in Fig. 3A) adapted to be driven by said first drive arrangement (108, 110, 112 in Figs. 1, 3A; and 114 in Figs. 1, 2A, 2B, 3A, 3B).

21. A cleaning device of claim 20, characterized in that said pair of support rollers (234 in Fig. 3A) have shafts (240, 242 in Fig. 3A) extending from said enclosure, said shafts (240, 242 in Fig. 3A) being driven by said first drive arrangement (108, 110, 112 in Figs. 1, 3A; and 114 in Figs. 1, 2A, 2B, 3A, 3B).

22. A cleaning device of any of the preceding claims, characterized in that said spray nozzle (116 in Figs. 1, 3A) is carried by a spray nozzle carriage (118 in Figs. 1, 3A, 3B) which engages a lead screw (120 in Figs. 1, 3A, 3B) connected to said second drive arrangement (120, 124 in Figs. 1, 3A, 3B; and 122 in Figs. 1, 2A, 3A, 3B) said lead screw (120 in Figs. 1, 3A, 3B) being enclosed by bellows (252, 254 in Fig. 3B) which are operable to expand and contract in accordance with the movement of said spray nozzle carriage (118 in Figs. 1, 3A, 3B).

23. A cleaning device of claim 22 characterized by a track (248 in Fig.3B) disposed adjacent to said lead screw (120 in Figs. 1, 3A, 3B), said spray nozzle carriage (118 in Figs. 1, 3A, 3B) having an arrangement for rollingly engaging said track (248 in Fig. 3B) whereby said nozzle carriage (118 in Figs. 1, 3A, 3B) is maintained in a stable upright position as said track (248 in Fig. 3B) is traversed.

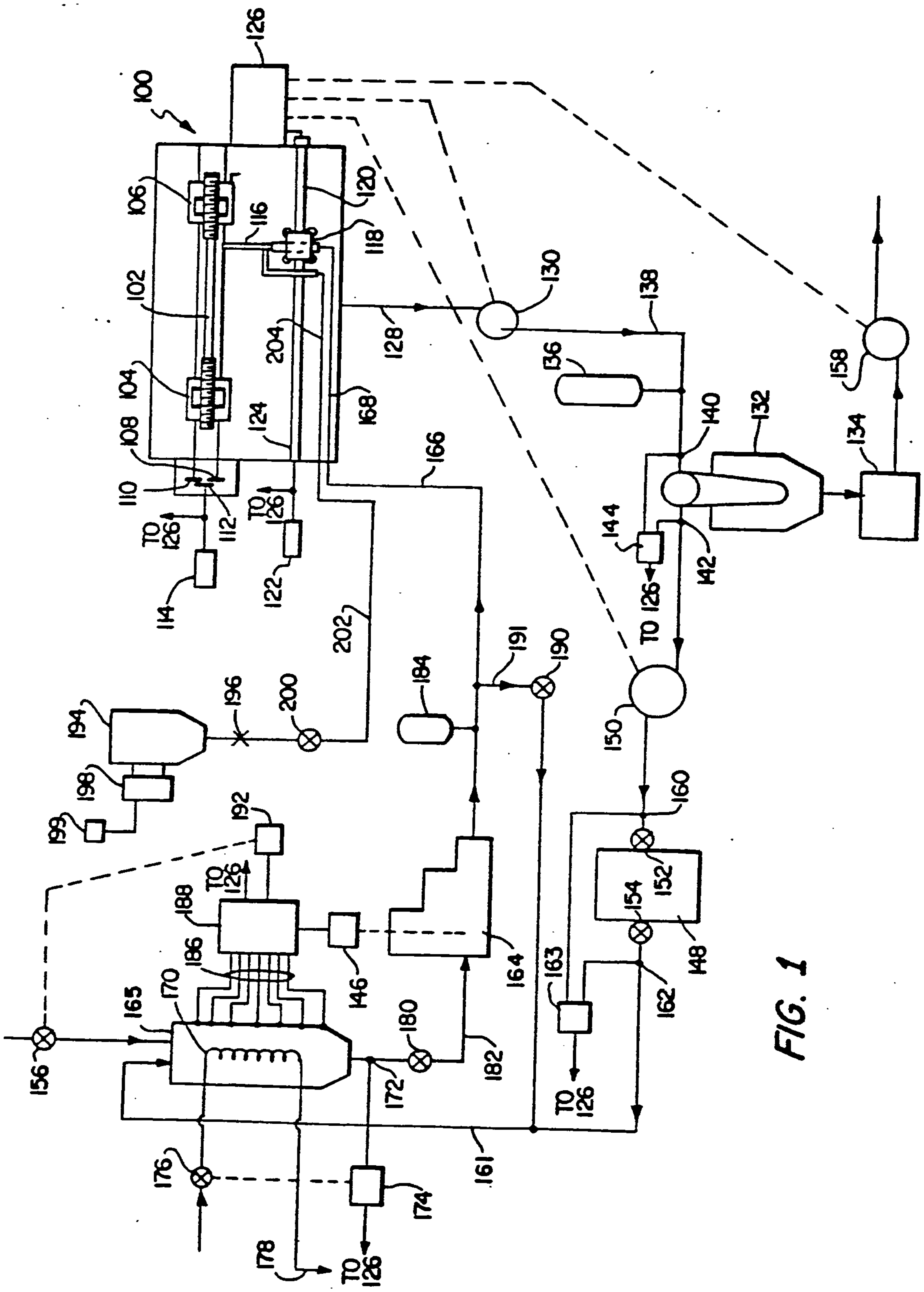
100
102
104
106
108
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
152
154
156
158
160
161
162
163
164
165
166
168
170
172
174
176
178
180
182
184
186
188
190
191
192
194
196
198
199
200
202
204
TO 126

FIG. 1

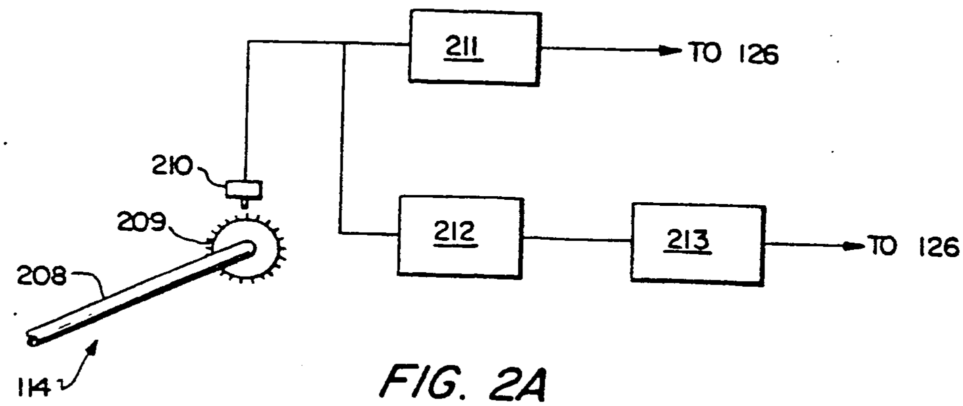
211
TO 126
210
209
212
213
TO 126
208
114

FIG. 2A

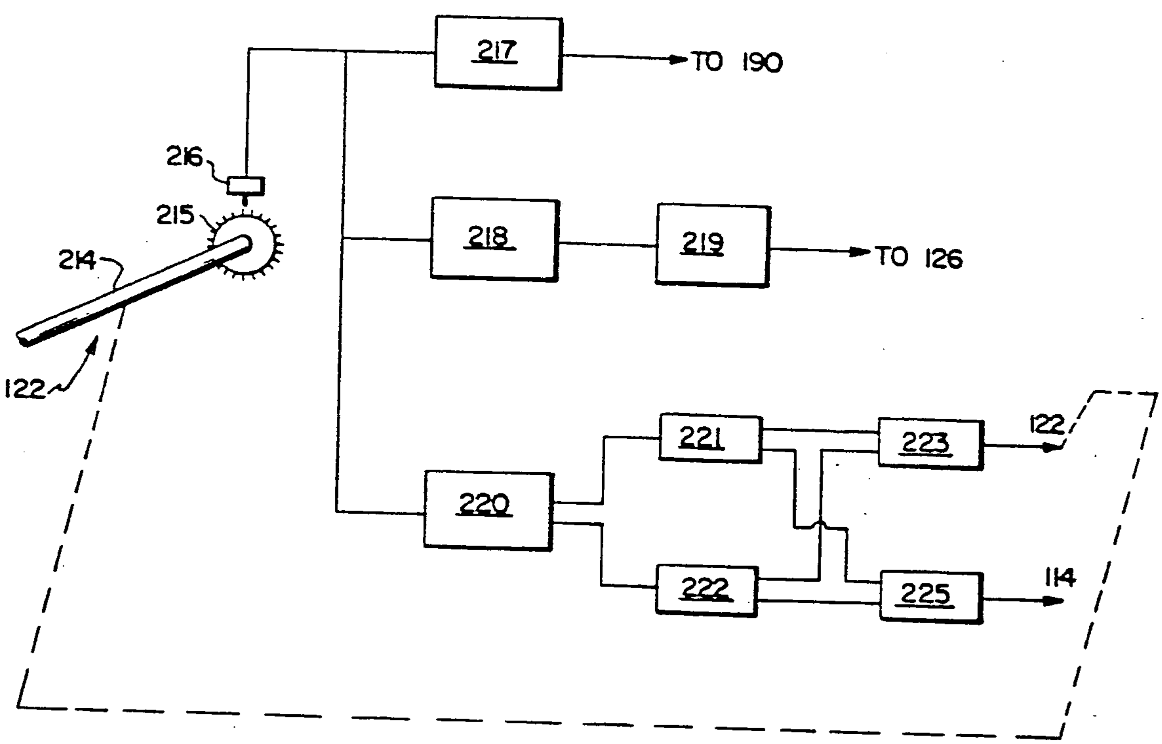
217
TO 190
216
215
214
218
219
TO 126
122
221
223
122
220
222
225
114

FIG. 2B

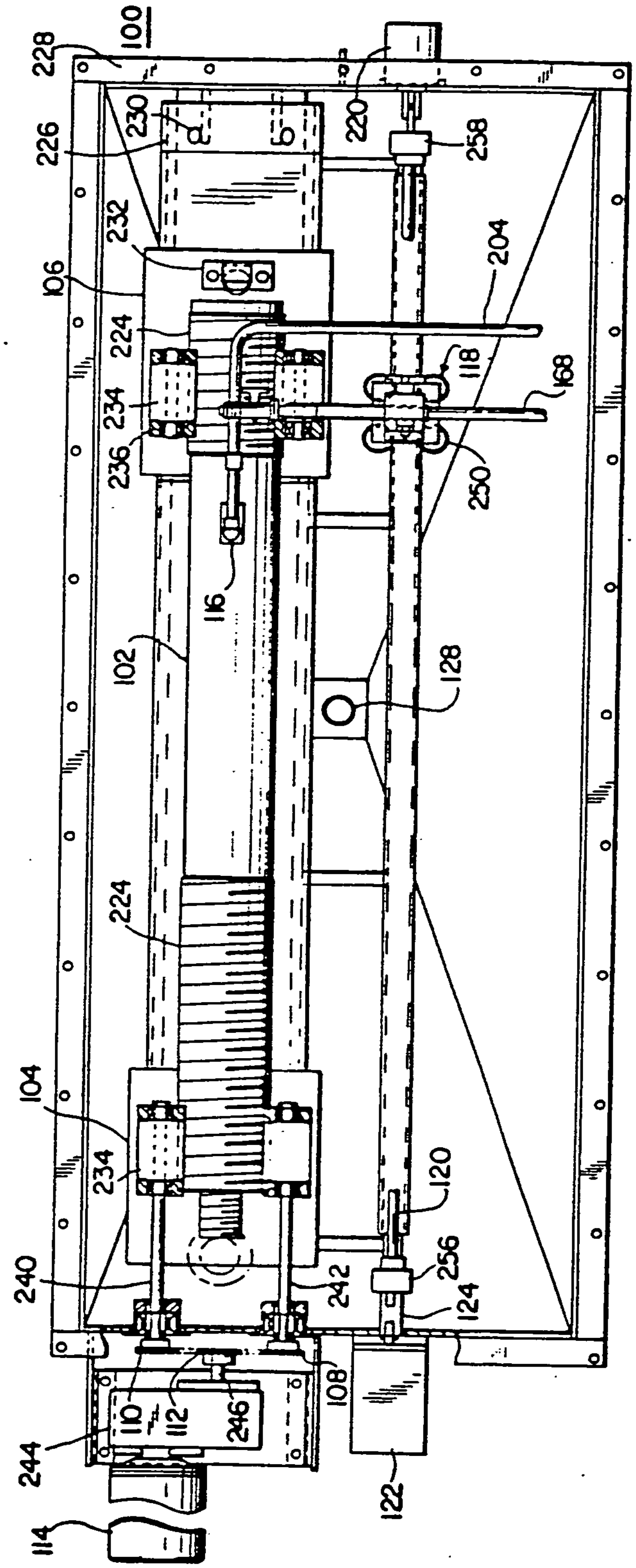
100
228
220
230
226
258
232
204
106
224
118
168
234
236
250
116
102
128
224
104
234
120
256
240
242
124
108
110
112
246
244
122
114

FIG. 3A

0144237

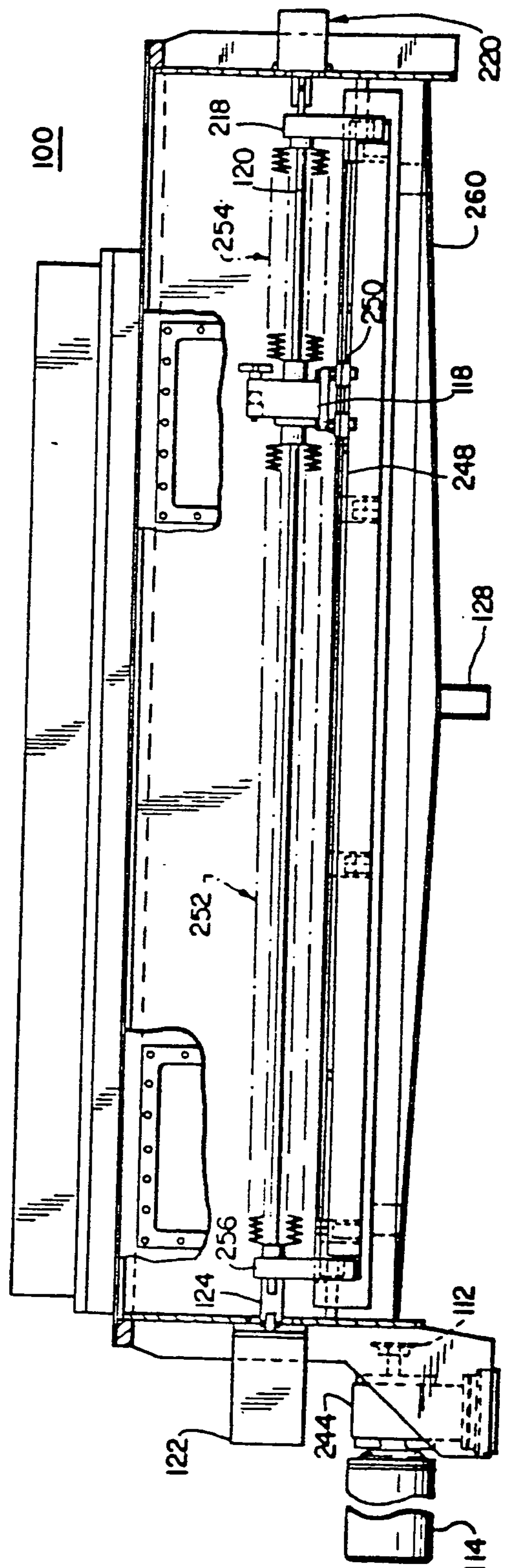

FIG. 3B